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(71) Applicant : KABUSHIKI KAISHA EGAWA
14-ban, Karayama-cho, 1-chome,
Chikusa-ku
Nagoya-shi (JP)

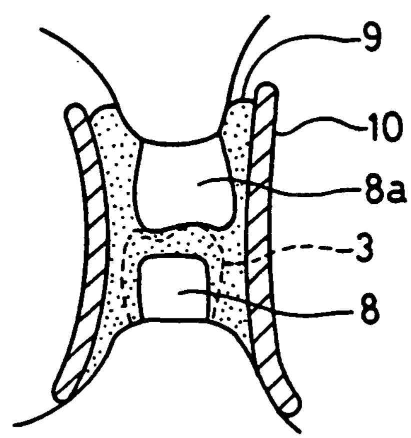
(72) Inventor : Nonomura, Yuusuke
14-ban, Karayama-cho 1-chome,
Chikusa-ku
Nagoya-shi (JP)

(74) Representative : Senior, Alan Murray et al
J.A. KEMP & CO.,
14 South Square
Gray's Inn
London WC1R 5LX (GB)

(54) A measuring method using resonance of a resonance body.

(57) As a method of measuring a sectional figure of a living body by using a resonance medium in the living body, a MRI device has been introduced. However, the MRI device is not applied to bones, teeth which are poor in resonance-related protons, electrons and molecules. According to the invention, electrical, magnetic and electromagnetic fields are applied to the bones and teeth using a resonance medium. By using the resonance of the resonance medium, figure and displacement of the bones and teeth are measured. In more detail, proton spin and electric spin are applied to the bones and the teeth so that the spin state is measured to specify the figure and displacement by means of the MRI device. Otherwise, a resonance circuit which comprises the resonance medium is applied to the bones and teeth which changes rotationally and linearly. The resonance circuit changes its resonance frequency according to the displacement of articles to be measured. As one example, LC resonance circuit is exemplified which changes its inductance and capacitance, and an antenna circuit which changes the length.
Frequency which is changed by an oscillating circuit is applied to the resonance circuit. The resonance frequency is read out by an output change from the oscillating circuit influenced by the resonance of the resonance circuit. On the basis of the resonance frequency of the resonance circuit, the displacement of the article are measured. Alternatively, an echo-back method may be applied.

Fig. 1



EP 0 602 970 A2

This invention relates to a method of measuring a figure, position and displacement of articles by artificially applying electrical, magnetic and electromagnetic fields, and well-suited for a dental therapy, but not limited to the dental therapy.

As a method of magnetically measuring a sectioned shape of a living body by using a resonance medium in the living body, a MRI device has been introduced. In a MRI device, a magnetic field is applied to the living body to control the spining direction of hydrogen protons so as to measure the sectional figure of the living body on the basis of the spin state (resonance state) by using resonance medium (mobile hydrogen protons, hydrogen nucleus mainly in H_2O) in the living body. Because the MRI device utilizes the hydrogen protons in the living body as a resonance medium, it is not possible to precisely measure articles which lack or are short of mobile hydrogen protons. As an example, it is not possible to precisely measure shapes of teeth and figures of lost portions of teeth at the time of dental therapy because of the shortage of the mobile hydrogen protons.

In the MRI device which utilizes the resonance of the living body, it is not possible to measure a displacement (rotational and linear) of changing portions in a non-living body. A potential meter has been known to measure a displacement (rotational and linear) of changing portions in a non-living body. In this potential meter, a resistance changes according to the changed position of the articles, and the rotational and linear displacements are measured on the basis of the voltage change due to the increase or decrease of the restistance In this case, the potential meter is electrically connected to a voltage measurement device via a lead wire. It is suggested that the voltage value measured by the potential meter is transformed into signals which are measured by a non-contact technique. However, a peripheral device of the potential meter unfavorably requires a large scaled architecture, complicated and heavy weight structure.

According to the present invention there is provided a measurement method using resonance of a resonance medium performed on an article which lacks or is short of hydrogen protons such as teeth, a prosthesis, a jaw bone in a mouth and an implant structure, the method including the step of preparing the article by providing the article with an MRI contrast medium which is rich in magnetic material and which is fluid at least when given to the article; and

measuring the MRI contrast medium by an MRI image device, and determining the shape of the article on the basis of the configuration in which the MRI contrast medium is or was in contact with the article.

According to the present invention there is also provided an MRI contrast medium which is rich in magnetic material, for supply to an article which lacks or is short of hydrogen protons, such as teeth, a prosthesis, a jaw bone in a mouth and an implant structure, the medium being fluid at least when given to the article.

Hence, there may be provided articles such as teeth, prosthesis, jaw bone in a mouth and implant structure each which lacks or is short of mobile hydrogen protons. These articles may be covered by a MRI contrast medium which contains a lot of magnetic material such as mobile hydrogen protons, and measured by a MRI device through the contrast medium. That is to say, these articles are measured via the contact surface of the contrast medium. This enables one to measure the shape of the articles such as teeth, prosthesis, jaw bone in a mouth and implant structure which lack or are short of mobile hydrogen protons.

In other words it is possible to measure the articles such as teeth, prosthesis, jaw bone in a mouth and implant structure which lack or are short of mobile hydrogen protons by means of the MRI device through the MRI contrast medium.

Where the articles are prepared teeth done by the dental therapy as an example of a preferable embodiment, the prepared teeth may be supplied by the MRI contrast medium, and shapes of the prepared teeth are measured by MRI image device. This enables one to precisely measure the shapes of the teeth without using an impression method of the prior art.

On the basis of the measured shape of the tooth, a shape of a prosthetic filler may be determined which is applied to the tooth. On the basis of the determined shape of the prosthetic filler, the prosthetic filler is three-dimensionally cut to provide the prosthetic filler.

According to one embodiment of the invention, a device for making crowning prosthetic filler may comprise: a MRI image device which measures a shape of tooth which is supplied by a contrast medium rich in mobile hydrogen protons; an electrical circuit which measures the shape of the tooth by the MRI image device through the contrast medium so as to determine the shape of the crowning prosthetic filler; a three-dimensional cutter which provides the crowning prosthetic filler on the basis of the shape determined by the electrical circuit; a measurement method is provided to measure the article by using the resonance of the resonance medium.

The crowning prosthetic filler may be directly provided by the shape of the tooth obtained from the MRI image device. This enables to precisely and quickly manufacture the crowning prosthetic filler compared to the prior art in which the impression method is used.

A root of a tooth in which dental pulp has been removed may be supplied with contrast medium rich in mobile hydrogen protons, and measured by the MRI image device. On the basis of the data from the MRI image device, a shape of the dental root may be measured to determine a specific shape of a prosthetic filler which is supplied to the dental root. From the determined shape of the dental root, the prosthetic filler is provided by means of a three-dimensional cutter.

The prosthetic filler may be directly provided from the shape of the dental root obtained from the MRI image device. This makes it possible to provide a long-lasting and stable prosthetic filler compared to the prior art in which a synthetic resin is supplied to the dental root.

A root of the tooth in which a dental pulp is removed may be supplied with a contrast medium rich in magnetic material, and measured by the MRI image device. On the basis of the data from the MRI image device, a shape of the dental root is measured to determine a shape of a prosthetic filler which is coated to the dental root. From the determined shape of the dental root, the prosthetic filler is provided by means of a three-dimensional cutter. This enables to directly provide the prosthetic filler from the shape of the dental root obtained from the MRI image device. This makes it possible to provide a long-lasting and stable prosthetic filler compared to the prior art in which a synthetic resin is coated to the dental root.

According to one embodiment of the invention, an insert probe may be inserted in a living body, and measured by the MRI image device. This enables one to provide a measuring method by using the resonance of the resonance medium in which the position of the insert probe is determined.

According further to the invention, the position of the insert probe may be measured by the MRI image device. This enables one to significantly improve the dental treatment technique.

According to the invention, there is also provided a device using resonance of a resonance medium comprising: a resonance circuit which changes frequency according to displacement of the articles; a resonant frequency measuring device provided to measure the position of the article on the basis of the resonant frequency obtained from the resonant frequency measuring device. This enables to measure the displacement of the article by non-contact means on the basis of the resonance frequency of the resonance medium. The resonance circuit is realized with a small scaled architect and light weight structure.

A measuring device using the resonance of the resonance medium may also comprise: a resonance circuit provided which changes a frequency according to displacement of the articles; a resonance frequency measuring device; a calculator device which calculates the position of the article on the basis of the resonance frequency obtained from the resonance frequency measuring device.

A measurement device may also make it possible to detect a displacement of the article by the resonance frequency of the resonance medium.

Thus the invention may provide a method of measuring articles which is capable of precisely measuring a figure by applying a resonance medium due to the spining action of the protons.

The invention may also provide a method of measuring articles which is capable of precisely measuring a figure by applying a resonance medium due to the electronic spin.

The invention may also provide a method of measuring articles which is capable of precisely measuring a figure with an electronic device through non-contact by applying a resonance medium. It may provide a method of measuring shape, position and displacement of the article by using the resonance of the resonance medium (protons, electrons, molecule and combination of these matters).

The invention will be more clearly understood from the following description given by way of example only with reference to the accompanying drawings in which:

Fig. 1 is a plan view for explaining a MRI contrast medium retained to a measuring cover according to a first embodiment of the invention;

Fig. 2 is an upper plan view for explaining a MRI contrast medium retained to a measuring cover according to the first embodiment of the invention;

Fig. 3 is a side elevational view of a cure tooth according to the first embodiment of the invention;

Fig. 4 is a schematic block diagram of a prostheic filler according to the first embodiment of the invention;

Fig. 5 is a cross sectional view of a cavity of the tooth in which the MRI contrast medium is provided according to a second embodiment of the invention;

Fig. 6 is a cross sectional view of a root of the tooth in which the MRI contrast medium is provided according to a third embodiment of the invention;

Fig. 7 is a cross sectional view of a root of the tooth in which the prostheic filler is provided according to the third embodiment of the invention;

Fig. 8 is a schematic perspective view of an implant structure according to a fourth embodiment of the invention;

Fig. 9 is a schematic perspective view of a prosthesis which is to be bonded to the implant structure according to the fourth embodiment of the invention;

Fig. 10 is a cross sectional view of the prosthesis in which a dental pulp is removed according to a fifth embodiment of the invention;

Fig. 11 is a cross sectional view of the tooth in which a prosthetic filler is coated to the dental root according to the fifth embodiment of the invention;

Fig. 12 is a cross sectional view of the tooth in which the MRI contrast filler is supplied according to a sixth embodiment of the invention;

Fig. 13 is a schematic perspective view of the implant structure according to a seventh embodiment of the invention;

Fig. 14 is a schematic view of a displacement measurement device according to a eighth embodiment of the invention;

Fig. 15 is a block diagram of the article to be measured according to the eighth embodiment of the invention;

Fig. 16 is a cross sectional view of an air variable capacitor according to the eighth embodiment of the invention;

Fig. 17 is a perspective view of an air variable capacitor according to a ninth embodiment of the invention;

Fig. 18 is a perspective view of an air variable capacitor according to a tenth embodiment of the invention;

Fig. 19 is a schematic view of a displacement measuring device according to an eleventh embodiment of the invention;

Fig. 20 is a perspective view of a variable coil according to the eleventh embodiment of the invention;

Fig. 21 is a perspective view of a coil according to a twelfth embodiment of the invention;

Fig. 22 is a schematic view of an antenna resonance circuit according to a thirteenth embodiment of the invention;

Fig. 23 is a schematic view of an antenna resonance circuit according to a fourteenth embodiment of the invention and;

Fig. 24 is a schematic view of an antenna resonance circuit according to a fifteenth embodiment of the invention.

Referring to Fig. 1 which shows a cure tooth 8 which is short of hydrogen protons, the tooth 8 is supplied by a MRI prosthetic filler 9 according to a first embodiment of the invention. In this instance, the tooth is supplied by the MRI prosthetic filler 9, but the thickness of the coating is freely selected as required. The shape of the tooth 8 is measured by a MRI image device as shown in Fig. 4 which indicates a schematic block diagram of a restoration device 1 to make a tooth restoration filler 3. The restoration device 1 has a MRI device 2 and an electrical circuit 4 which determines the shape of the tooth restoration filler 3 (see Fig. 3) on the basis of the information from the dental shape obtained by the MRI device 2. A three-dimentional cutter 5 is adapted to define the shape of the tooth restoration filler 3. The MRI device 2 is a well-known structure, and having a magnetic field generator device, a magnetic resonance reading device which reads spin state or electronic spin state of hydrogen protons. A shape measuring device is provided to detect the presence of the hydrogen protons from the magnetic resonance read out by the magnetic resonance reading device, and calculating a shape in which the hydrogen protons are present. The calculated shape is monitored by an external display device 6. The MRI image device 2 is operated by an operator through the electrical circuit 4 and an external device 7. In the MRI image device 2, the cure tooth 8 is supplied with the MRI prosthetic filler 9, and the shape of the MRI prosthetic filler 9 is measured to read out the shape of the cure tooth 8. The MRI prosthetic filler 9 is filled between the cure tooth 8 and a measurement cover device 10 which is applied to the outer surface of the cure tooth 8 as shown in Fig. 1 through 3. The measurement cover device 10 is provided to support the MRI prosthetic filler 9 at both sides of the tooth 8 at the time of measuring the shape of the tooth 8. In this instance, care should be taken not to interfere the occlusion of the teeth particularly when examining occlusive positions such as central occlusion, eccentric occlusion and the like in which a tooth 8a occludes the tooth restoration filler 3 which is applied to the cure tooth 8. When the shape of the tooth 8 and the occlusive position are measured by the MRI image device 2, the tooth 8 is covered by the measurement cover device 10. Then the MRI prosthetic filler 9 is supplied inside the measurement cover device 10 so as to completely coat an outer surface of the tooth 8. The MRI prosthetic filler 9 includes inorganic and organic substance such as agar, alginate, silicon rubber and hydrocarbon which are rich in mobile hydrogen protons (mainly in H_2O). The MRI prosthetic filler 9 is in the fluid (or semi solid) state at least when placed in the mouth to coat the cure tooth 8. The MRI prosthetic filler 9 is favorable when it is not solidified in the mouth particularly upon measuring the consecutive occlusive positions of the teeth. When the MRI contrast medium is solidified in the mouth, the solidified MRI contrast medium collapses upon changing the occlusive position of the teeth. When consecutively changing the occlusive position of the teeth, the MRI prosthetic filler 9 may be constantly supplied inside the measurement cover device 10 so as to avoid the clearance around the cure tooth 8 by using a syringe by way of an example. When it is necessary to prevent measurement errors due to the displacement of the patient jaw, the MRI contrast medium may be fluid when the contrast medium is in the mouth to coat the cure tooth, and contrast medium may preferably be solidified after coating the cure tooth. When the tooth 8 is supplied by the MRI prosthetic filler 9, the prosthetic filler 9 is measured by the MRI device 2, and the shape of the pretared tooth is detected by the figure of the prosthetic filler 9 which is in direct contact with the cure tooth 8. It is noted that in the above description, the inner shape of the MRI contrast medium 9 is measured with the cure tooth 8 covered by the MRI contrast medium 9, however, the MRI contrast medium 9 may be solidified in the mouth, and the solidified medium 9 is taken out of the mouth to be measured by the MRI image processing device 2. The MRI contrast medium 9 taken out of the mouth may be supplied with a discrete MRI contrast medium, and an interface between the two MRI contrast media is measure by the MRI image processing device 2 so as to determine the shape of the cure tooth 8. In this instance, a discrete medium may be provided in an inner side of the contrast medium 9 separated from the cure tooth so as to indirectly measure the shape of the cure tooth 8 by way of the newly proviced medium. Thus, measuring the MRI contrast medium 9 outside the mouth makes it possible to avoid from directly applying the MRI image processing device 2 to the client, and thus protecting the client against psychological obtrusiveness intrusiveness caused from directly applying the MRI image processing device 2 to the client. When the discrete contrast medium is supplied to the MRI contrast medium 9, it is possible to use a MRI contrast medium inappropriate to the mouth because the contrast medium is harmful to the mouth by way of illustration.

In the electrical circuit 4, the electrical circuit 4 has a tooth shape read-out device 11 which reads the shape of the tooth from the spin state of the protons in the MRI prosthetic filler 9. A tooth shape display device 12 is provided to display the shape of the tooth read out by the tooth shape read-out device 11 through a monitor device 6. By observing the shape of the tooth on the monitor device 6, the external device 7 is operated to specify the bonding shape matching to the cure tooth 8 by a bonding shape determining function 13. By considering the occlusive position of the teeth, the shape of the MRI prosthetic filler 9 is simulated by the operation of the external device 7 by an outer shape determining function 14. From the bonding shape specified by the bonding shape determining function 13 and the outer shape determined by the outer shape determining function 14, the shape of the MRI prosthetic filler 9 is determined by a restoration filler shape determining function 15.

The electrical circuit 4 has a pretaring control function 16 which controls the three-dimensional cutter 5 to provide an outer shape of the MRI prosthetic filler 9 specified by the restoration filler shape determining function 15. The pretaring control function 16 and the three-dimensional cutter 5 enable to provide the tooth restration filler 3 from various type of metals, ceramic material and the like.

According to the first embodiment of the invention, the shape of the MRI prosthetic filler 9 is precisely measured by coating the cure tooth with the MRI prosthetic filler 9 although it is difficult to directly measure the cure tooth by the MRI image device. From the shape of the MRI prosthetic filler 9 which is in contact with the cure tooth 8, the shape of the cure tooth 8 and various types of the occlusive positions between the cure tooth 8 and the tooth 8a are precisely measured. From the pretared shape of the cure tooth and information of the occlusive positions, the shape of the tooth restoration filler 3 is determined so as to manufacture the tooth restoration filler 3 by CAD (computer-aided machine). The restoration device 1 enables to make the tooth restoration filler 3 on the basis of the precisely measured tooth shape without using the impression method. This makes it possible to precisely and quickly manufacture the tooth restoration filler 3 compared to the prior art in which the impression is used in the patient mouth.

Fig. 5 show a cross sectional view of the tooth 8 which has a cavity 17 provided on the tooth 8 at the time of curing the tooth 8 according to a second embodiment of the invention. The cavity 17 is filled with the MRI prosthetic filler 9, and the shape of the cavity 17 is measured by using the MRI image device 2. It is appreciated that the tooth restoration filler 3 is precisely and quickly manufactured on the basis of the figure of the cavity 17 by using the restoration device 1. A distance between the cavity 17 and a dental pulp 18 of the cure tooth 8 is measured by filling the cavity 17 with the MRI prosthetic filler 9 and using the MRI image device 2 because the dental pulp 18 is rich in mobile hydrogen protons. In the prior art in which the pretaring amount of the cavity 17 and the distance between the cavity 17 and the dental pulp 18 of the cure tooth 8 are not measured, the dental pulp is often pretared inadvertently. According to the invention, the pretaring amount of the cavity 17 and the distance between an inner wall of the cavity 17 and the dental pulp 18 of the cure tooth 8 are measured respectively. This apparently makes it possible to prevent the dental pulp from being pretared inadvertently.

Fig. 6 shows a cross sectional view of the cure tooth 8 in which the dental pulp in a pulp root canal 19 is removed by a reamer, a file or the like. Within the pulp root canal 19 in which the dental pulp is removed, the MRI prosthetic filler 9 is filled, and the shape of the pulp root canal 19 is measured by using the well-known MRI image device 2. By using the restoration device 1, tooth restoration filler 19a which fills the pulp root canal 19 is precisely and quickly made on the basis of the measured figure of the pulp root canal 19.

In the prior art in which a synthetic resin is provided with dental root from which the dental pulp is removed, tissue change and dead voids often appear in the tooth to finally result in inflammation. With the use of the MRI prosthetic filler 9 in combination with the MRI image device 2, it is possible to cure the dental root without any tissue change and dead voids in the tooth so as to prevent occurrence of the inflammation.

Fig. 8 shows an implant structure 20 which is attached to a jaw bone to serve as an article to be measured according to an eighth embodiment of the invention. The implant structure 20 is supplied by the MRI prosthetic filler 9. By measuring the prosthetic filler 9 with the MRI image device 2, the position and the direction of a screw hole 22 are determined in attaching a prosthesis 21 to the implant structure 20. On the basis of the position and the direction of the screw hole 22, a throughhole 24 in which a screw 23 passes is formed on the prosthesis 21 by using the three-dimemsional cutter such as CAD (computer-aided machine) as shown in Fig. 9.

Fig. 10 shows the cure tooth 8 in which a pretaring probe (insert probe) 31 is inserted to remove the dental pulp 18 inside the pulp root canal 19. As one example of curing the pulp root canal 19, the dental pulp is exposed by pretaring the cure tooth 8. Then the pretaring probe 31 such as a reamer, a file or the like is inserted in the dental pulp 18. In this instance, the pretaring probe 31 is made of flexible and magnetic metal or oxide of such as Fe, Co, Cu, Ni, Cr, Mn, Sr, Sm and Nd or alloy of these magnetic metals such as a stainless steel. Upon inserting the pretaring probe 31 in the dental pulp 18, the MRI image device 2 is operated to show the cure tooth 8 (pulp root canal 19 in particular) or a section of the pulp root canal 19 by means of the three-dimensional structure. The hard portions such as dentin and enamel of the cure tooth 8 can not be measured by the MRI image device 2, the pretaring probe 31 however is measured by the MRI image device 2 because of the electronic spin. A gum 36, the dental pulp 18, the dental root 33 and a dental root membrane 35 between the dental root 33 and alveolus bone 34 are measured by the MRI image device 2 to clearly show the pretaring probe 31, the gum 36, the dental pulp 18 and the dental root membrane 35 on the monitor device 6.

By confirming the insert amount of the insert probe 31, the operator reaches a leading end of the insert probe 31 to the dental root base. Then the operator manipulates a stopper (not shown) not to proceed the leading end of the insert probe 31 inside the cure tooth 8. After the end of this manipulation, the dental pulp 18 is removed by the insert probe 31. The operator can initiate the cure of the tooth 8 after confirming that the insert probe 31 reaches the dental root base, and that the leading end of the insert probe 31 is not beyond the pulp root canal 19 of the cure tooth 8. This makes it possible to readily remove the dental pulp 18 without letting the probe 31 go beyond the pulp root canal 19 and without remaining the dental pulp 18 inside the cure tooth 8.

In this embodiment of the invention, the insert amount of the pretaring probe 31 is firstly measured to remove the dental pulp 18. Upon removing the dental pulp 18, the cure tooth 8 (pulp root canal 19 in particular) is shown on the monitor device 6 by operating the MRI image device 2, and then the dental pulp 18 may be removed from the end base of the pulp root canal 19 while on the other hand confirming the insert amount of the pretaring probe 31 as indicated in Fig. 10. This also makes it possible to readily remove the dental pulp 18 without letting the probe 31 go beyond the pulp root canal 19 and without remaining the dental pulp 18 inside the cure tooth 8. This further makes it possible to effectively prevent the pretaring probe 31 from pushing out the dental pulp 18 out of the pulp root canal 19. In measuing an inside figure of the pulp root canal 19 from which the dental pulp 18 is removed, the inside of the pulp root canal 19 is filled with a fluid (or semi solid) but MRI contrast medium 40 which is rich in magnetic material by using the syringe, lentulo or the like. A MRI contrast medium 40 is in the fluid state at least when the outer surface of the pulp root canal 19 is supplied by the MRI contrast medium 40. After coating the pulp root canal 19, the MRI contrast medium 40 may be solidified without keeping the fluidity. It is preferable that the MRI contrast medium 40 may be readily removed after measuring it by using the MRI image device 2. By way of illustration, the MRI contrast medium 40 may be made by dispersing the magnetic material into water-soluble substance such as agar, otherwise dispersing it into the gum-like resin.

As examples of the magnetic materials, oxides or the metals of Fe, Co, Ni, Cu, Cr, Mn, Sr, Sm, and Nd are used in the powdered or ionized (chelated) form. In the case of the minutely powdered form, Samarium, Cobalt, Ferrite, Alnico, Permalloy, Sendust (trademark) and Fe-Si-B and Nd-Fe-B may be used as the magnetic materials.

When the MRI image device examines the cure tooth 8 in which the pulp root canal 19 is supplied with the MRI contrast medium 40, the shape of the pulp root canal 19 is clearly shown due to the electronic spin in the MRI contrast medium 40. The electrical circuit 4 has the same structure as described in the first embodiment of the invention. Namely, the electrical circuit 4 includes the tooth shape read-out device 11 which reads the inner shape of the contrast medium 40 which is in direct contact with the cure tooth 8 on the basis of the shape of the MRI contrast medium 40 obtained by the MRI device 2. The tooth shape display device 12 is provided which displays the tooth figure read out on the monitor device 6 by the tooth shape read-out device 11. The restoration filler shape determining function 15 is provided to determine its shape from the outer shape defined by the outer shape determining function 14 and the bonding shape defined by the bonding shape determining function 13. The electrical circuit 4 has the pretaring control function 16 which controls the three-dimensional cutter in order to make a tooth restoration filler 19a on an output of the basis of the restoration filler shape determining function 15. The tooth restoration filler 19a is made of metals, ceramic materials, hard resin and the like as seen in Fig. 7. It is noted that an optical projector may be used when the tooth restration filler 19a is made of the resin. It is also noted that the tooth restoration filler 19a is supported inside the pulp root canal 19 by means of an adhesive as shown in Fig. 3.

According to the fifth embodiment of the invention, the pretaring probe 31 inside the pulp root canal 19 is measured through the MRI device 2 by making the pretaring probe 31 from the magnetic material, although it is usually difficult for the MRI image device 2 to measure the inside the pulp root canal 19 from which the hard portion 32 and the dental pulp 18 is removed because the inside of the pulp root canal 19 is short of the mobile hydrogen protons. This enables to precisely remove the dental pulp 18 so as to significantly improve the dental therapeutical technique. Instead of the resin which has been used in the prior art, the inside of the pulp root canal 19 is filled with the hard substance filler. This makes it possible to effectively protect the inside the tooth against the tissue change and the dead voids which otherwise would cause the inflammation for a long period of time. With the use of the MRI contrast medium 40 and the MRI device 2, the shape of the tooth restoration filler 19a is determined on the basis of the inside figure of the pulp root canal 19 so as to make the tooth restoration filler 19a by using CAM (computer-aided manufacturer). This enables to precisely and quickly make the tooth restoration filler 19a.

As a modification form of the fifth embodiment of the invention in which the pretaring probe 31 is used to mill the dental pulp of the cure tooth, a rotary type of a pretaring probe may be used to cure the tooth. A candid camera, polyp removing tool, curettage, extractor, catheter sonde other probe may be used which are respectively inserted in the bone structure, stomach, intestine, nostril, blood vessel and the like. This is particularly effective in measuring the position of the pretaring probe when it is inserted in the living body in which a dilated space is provided by pneumatic means. This is also advantageous when measuring the position of the pretaring probe inserted in bone tissue and subnostril which are usually thought difficult to examine by the MRI image device. It is noted that a magnetism-laden insert probe may be used, and a resin-dispersed insert probe may be employed. It is appreciated that magnetism may be laden on a part of the insert probe to confirm the specified position of the insert probe. It is also appreciated that the MRI contrast medium 40 may be supplied to the dental pulp before removing it to clearly examine the dental pulp 18. It is noted that it is possible to measure the jaw bone in the mouth which are relatively poor in the mobile hydrogen protons instead of the examples in which the shape of the dental root and the dental pulp are measured by means of the MRI contrast medium 40. It is further noted that a fluid contrast medium may be employed to thinly apply it to the article by means of splay coating or brushing when the MRI contrast medium 40 is used as a magnetic material.

Fig. 12 shows the cure tooth 8 which has a cavity 17 provided at the time of curing the tooth 8 according to a sixth embodiment of the invention. In the cavity 17, the MRI contrast medium 40 is supplied to measure the shape of the cavity 17 by the MRI image device 2. By using the restoration device 1 of the first embodiment of the invention, the shape of the tooth restoration filler is precisely and quickly provided on the basis of the measured shape of the cavity 17. Further, the distance between an inner wall of cavity 17 and the dental pulp 18 is measured by supplying the MRI contrast medium 40 in the cavity 17 and measuring its shape through the MRI image device 2.

Fig. 13 shows the implant structure 20 to serve as an article to be measured according to a seventh embodiment of the invention. The implant structure 20 is supplied by the MRI contrast medium 40. By measuring the implant structure 20 through the MRI contrast medium 40, it is possible to measure the direction and the position of the screw hole 22 through which the prosthesis 21 (Fig. 9) is attached to the implant structure 20. On the basis of the determined position and direction of the screw hole 22, the throughhole 24 is provided with the prosthesis 21 through which the screw 23 passes to attach the prosthesis 21 to the implant structure 20 by using the three-dimensional cutter such as CAM (computer-aided machine).

Fig. 14 shows a displacement measuring device 41 according to an eighth embodiment of the invention. The displacement measuring device 41 is provided to detect a rotational angle as one examaple of a displacement factor. The displacement measuring device 41 has an LC-resonance circuit 43 which is attached to an article 42 (Fig. 15) which changes its angle. A resonance frequency measuring device 44 is provided to detect the resonance frequency of the LC-resonance circuit 43. A calculator device 45 is provided to detect the rotational angle of the article 42 on the basis of the detected resonance frequency. An indicator device 46 is provided to display the calculated rotational angle of the article 42. The article 42 serves as a mechanical element in which a second member 48 rotationally moves in relative to a first member 47.

In the LC-resonance circuit 43, a variable capacitor 49 and a coil 50 are provided in which the capacitor 49 changes its capacitance according to the rotational movement between the second member 48 and the first member 47. The LC-resonance circuit 43 changes its resonance frequency according to the angular movement between the second member 48 and the first member 47. The variable capacitor 49 is in the form of an air variable capacitor, and having a plurality of stationary electrodes 51 connected to the first member 47 and a plurality of movable electrodes 52 connected to the second member 48. The overlapping area between the stationary electrodes 51 and the movable electrodes 52 changes to vary the capacitance according to the angular movement between the second member 48 and the first member 47. It is noted that the various types of the variable capacitors are introduced as follows:

(1) A linear capacity type which linearly changes the capacity according to the rotational angle.

(2) A liner wave type which changes its resonance wave according to the rotational angle.

(3) A linear frequency type which changes its resonance frequency according to the rotational angle.

(4) An exponential type which changes its capacity, wave or frequency according to the rotational angle.

Among these various types, it is readily used when the LC-resonance circuit 43 linearly changes its resonance frequency according to the rotational angle. It is noted that the coil 50 may be selected among air core type or magnetic core type coils. The coil 50 may be a variable coil which changes its inductance.

When the variable coil is selected, the coil acts not to change its inductance according to the rotational angle, but works to change the resonance zone of the resonance frequency. This type enables to eliminate to overlap the resonance frequency among each of the LC-resonance circuits 43 when detecting angles of a plurality of the articles 42. When a stationary type of coil is used as the coil 50, it is possible to change the resonance zone of the resonance frequency by adding a capacitor and a coil to the LC-resonance circuit 43.

On the other hand, the resonance frequency measuring device 44 is adapted to measure the resonance frequency of the LC-resonance circuit 43 by using non-contact technique of a dip meter as one example. The dip meter has an oscillating circuit 53 which transmits a consecutively changing oscillating frequency. A current measuring device 54 is provided to measure the intensity of current which is used to oscillate the oscillating circuit 53. In the dip meter, the oscillating frequency of the oscillating circuit 53 is consecutively changed within the resonance frequency zone of the LC-resonance circuit 43. When the oscillating frequency of the oscillating circuit 53 corresponds to the resonance frequency of the LC-resonance circuit 43, the current measured by the current measuring device 54 drops due to the resonance phenomenon. That is to say, the oscillating frequency in which the current drops serves as the oscillating frequency of the LC-resonance circuit 43.

In the calculator device 45, the rotational angle of the article 42 is measured on the basis of the resonance frequency since the resonance frequency of the LC-resonance circuit 43 corresponds to the rotational angle of the article 42. In this instance, the rotational angle of the article 42 is measured on the basis of the rotational angle and the resonance frequency previously determined by experimental test results. The rotational angle of the article 42 determined by the calculator device 45 is displayed via the indicator device 46. When the rotational angle of the article 42 changes constantly, the rotational angle is read by controlling the dip meter through a computer. This holds true when the rotational angle of the article 42 changes rapidly, and a plurality of rotational angles are detected concurrently. That is to say, the sweep speed of the oscillating circuit 53 is controlled by the computer, and at the same time, the current change of the current measuring device 54 is read every sweep by the computer. In this instance, the sweep speed signifies to consecutively change the oscillating frequency. On the basis of the oscillating frequency in which the current drops, the resonance frequency of the LC-resonance circuit 43 is measured to determine the rotational angle of the article 42. It is noted that the rotational angle of the article 42 measured by the computer may be used as an input signal for various types of controller devices. When the rotational angle of the article 42 is used as the input signal, the resonance frequency may be employed as the rotational angle of the article 42.

With the structure thus described, the capacitance of the variable capacitor 49 of the LC-resonance circuit 43 changes when the second member 48 rotates relative to the first member 47. The changed capacitance causes to vary the resonance frequency of the LC-resonance circuit 43. The article 42 causes to continuously change the resonance frequency within the resonance frequency zone of the LC-resonance circuit 43 due to the oscillating circuit 53. When the oscillating frequency of the oscillating circuit 53 corresponds to the resonance frequency of the LC-resonance circuit 43, the current measured by the current measuring device 54 drops due to the resonance phenomenon. On the basis of the dropped current, the rotational angle of the article 42 is calculated by the calculator device 45. The calculated angle is displayed on the indicator device 46.

According the eighth embodiment of the invention, the rotational angle of the article 42 is measured by non-contact technique. The LC-resonance circuit 43 consists of only the variable capacitor 49 and the coil 50 so that the whole structure of the LC-resonance circuit 43 is small scale and light weight and simple in structure. That is to say, the LC-resonance circuit 43 contributes to space-saving, cost-saving and help to lighten the burden of the article 42 when it is attached to the article 42.

Fig. 17 shows the variable capacitor 49 according to a ninth embodiment of the invention. The variable capacitor 49 serves as a cylinder type of air variable capacitor, and having an outer cylinder 55 connected to the first member and an inner cylinder 56 connected to the second member. The overlapping area of the outer cylinder 55 and the inner cylinder 56 changes depending on the relative movement of the first member and the second member so as to vary the capacitance.

Fig. 18 shows the variable capacitor 49 according to a tenth embodiment of the invention. The variable capacitor 49 is in the form of a slider type capacitor which is applied to a displacement detecting device so as to detect the movement of the first member and the second member. The variable capacitor 49 has an outer cylinder 61 connected to the first member and an inner cylinder 62 connected to the second member. A linear change of the first member and the second member causes to vary an overlapping area between a stationary electrode of the outer cylinder 61 and a movable electrode of the inner cylinder 62 so as to change the capacitance. On the basis of the changed capacitance, the linear change of the first member and the second member is measured in the same manner as described in the ninth embodiment of the invention. It is noted that each of the stationary electrode and the movable electrode may be laminated like multi-layer configuration.

Fig. 19 shows a schematic view of the displacement measuring device 41 according to an eleventh embodiment of the invention. In the LC-resonance circuit 43, in addition to a capacitor 49a, a variable coil 50a is employed to change its inductance depending on the relative movement between the first member and the second member. The variable coil 50a works to measure the linear movement of the article, and having a cylinder coil 63 connected to the first member and a magnetic core 64 connected the second member as shown in Fig. 20. The insert amount of the magnetic core 64 to the coil 63 changes to vary its inductance depending on the linear movement of the first member and the second member. That is to say, the resonance frequency of the LC-resonance circuit 43 changes depending on the linear movement of the first member and the second member. On the basis of the changed resonance frequency, the linear movement of the first member and the second member is measured. It is noted that the capacitor employed herein may be a stationary type and a variable type. When the variable type of capacitor is selected, it is possible to change the resonance frequency zone by predeterming the capacitance of the capacitor arbitarily.

Fig. 21 shows a schematic view of the variable coil 50a according to a twelfth embodiment of the invention. In a resonance circuit of the twelfth embodiment of the invention, the resonance circuit consists of only the variable coil 50a without using any capacitor as an electronic device. The resonance circuit has the cylinder coil 63 connected to the first member and the magnetic core 64 connected the second member in the same maner as described in the eleventh embodiment of the invention. Although the resonance circuit dispenses without any capacitor according to the eleventh embodiment of the invention, the resonance circuit substantially form an LC-resonance circuit when considering a self-capacitance of the cylinder coil 63.

Fig. 22 shows a schematic view of an antenna resonance circuit 70 in which a received frequency changes depending on the movement of the article according to a thirteenth embodiment of the invention. The antenna resonance circuit 70 has a cylinder rod 71 connected to the first member of the article and an elongation rod 72 connected the second member. A linear movement of the first member and the second member causes to change the insert amount of the elongation rod 72 to cylinder rod 71 so as to vary the resonance frequency (received frequency). That is to say, the resonance frequency of the antenna resonance circuit 70 changes depending on the linear movement of the first member and the second member. On the basis of the changed resonance frequency, the linear displacement of the first member and the second member is determined.

Fig. 23 shows a schematic perspective view of the antenna resonance circuit 70 according to a fourteenth embodiment of the invention. In the antenna resonance circuit 70 according to a fourteenth embodiment of the invention, there is provided a cylindrical body 74 connected to the first member. A plurality of looped antennas 73 are disposed in the cylindrical body 74 at regular intervals. An elongated magnetic core 75 is connected to the second member, and axially movably disposed in the cylindrical body 74. In the antenna resonance circuit 70, the resonance frequency changes depending on the insert amount of the core 75 to the cylindrical body 74 so as to continuously measure the positional relationship between the first member and the second member even when a leading end of the core 75 is located between the neighboring looped antennas 73.

Fig. 24 shows a schematic perspective view of an antenna resonance circuit 70 according to a fifth embodiment of the invention. In the antenna resonance circuit 70 according to a fifth embodiment of the invention, there is provided a cylindrical body 77 connected to the first member. A plurality of coiled antennas 76 are disposed in the cylindrical body 77 at regular intervals. An elongated magnetic core 78 is connected to the second member, and axially movably disposed in the cylindrical body 77.

It is observed that any type of an air variable capacitor may be used except for ones employed in the eighth ~ fifteenth embodiments of the invention. A magnetically variable capacitor, poly variable capacitor, trimer capacitor may be used as alternative variable capacitors.

In the eleventh and twelfth embodiments of the invention, the linear movement is measured by changing the inductance depending on the displacement of the article, it is possible to measure the rotational angle by changing the capacitance depending on the rotational movement of the article.

It is also observed that a resistor may be added to the LC-resonance circuit in the eighth ~ twelfth embodiments of the invention.

In the thirteenth ~ fifteenth embodiments of the invention, the received frequency is changed according to the linear movement of the article so as to measure the linear displacement. It is appreciated that it is possible to change the received frequency depending on the rotational movement of the article so as to measure the rotational angle. It is also possible to treat the resonance frequency as a displacement of the article since the resonance frequency corresponds to the displacement of the article.

In the above embodiments of the invention, the resonance frequency is measured by supplying voltage to the oscillating circuit. It is possible to generate pulse signals (in the form of rectangular wave) at the resonance frequency measurement device. This makes it possible to measure a length of echo due to the resonance of the resonance circuit. In this instance, it is also possible to adop the echo-back method in which an intensity of the echo is measured to detect the resonance frequency. It is noted that a high frequency bridge measurement method may be adopted.

It is further noted that it is possible to transmit the resonance frequency from the resonance circuit so that the resonance frequency measuring device receives the resonance frequency.

The resonance circuit is made from the electronic device in the above embodiments of the invention, the resonance circuit may be made from molecular level and crystallization body. In this instance, L, LC and LCR resonance circuit may be made of the molecular level and the crystallization body, or otherwise the circuit may be made of an equivalent circuit. These types of the circuits are well-suited for sensors of micromachines.

While the invention has been described with reference to the specific embodiments, it is understood that this described is not to be construed in a limiting sense in as much as various modifications and additions to the specific embodiments may be made by skilled artisan without departing from the spirit and scope of the invention.

Claims

1. An MRI contrast medium which is rich in magnetic material, for supply to an article which lacks or is short of hydrogen protons, such as teeth, a prosthesis, a jaw bone in a mouth and an implant structure, the medium being fluid at least when given to the article.

2. A measurement method using resonance of a resonance medium performed on an article which lacks or is short of hydrogen protons such as teeth, a prosthesis, a jaw bone in a mouth and an implant structure, the method including the steps of:

   preparing the article by providing the article with an MRI contrast medium which is rich in magnetic material and which is fluid at least when given to the article; and

   measuring the MRI contrast medium by an MRI image device, and determining the shape of the article on the basis of the configuration in which the MRI contrast medium is or was in contact with the article.

3. An MRI contrast medium according to claim 1 or a measurement method according to claim 2 wherein the MRI contrast medium is retained around the article by a measurement cover which covers the article.

4. A measurement method according to claims 2 or 3 wherein the article is a cure tooth which is prepared at the time of treating the tooth, the tooth being supplied with the MRI contrast medium, and a shape of the prepared tooth being measured by the MRI image device.

5. A measurement method according to claim 2, 3 or 4 wherein the article is a cure tooth which is prepared at the time of treating the tooth, the tooth being supplied with the MRI contrast medium, and a distance between a preparing position and a dental pulp of the cure tooth being measured by the MRI image device.

6. The measurement method according to claim 2, 3, 4 or 5 wherein the MRI contrast medium is located between an upper tooth and a lower tooth, and measured by the MRI image device so as to determine a central occlusive position and an eccentric occlusive position of the upper and lower teeth.

7. A measurement method according to any one of claims 2 to 6 wherein the article is an implant structure which is to be attached to a jaw bone, the implant structure being supplied with the

MRI contrast medium to determine a bonding position in which a prosthesis is attached to the implant structure by using the MRI image device.

8. A measurement method according to any one of claims 2 to 7 wherein the article is a dental root of the cure tooth from which a dental pulp is removed, the dental root being supplied with the MRI contrast medium, and a shape of the dental root being measured by the MRI image device.

9. A method for forming a prosthetic filler in which a prepared tooth is supplied with an MRI contrast medium, which is rich in magnetic material, and is measured by an MRI image device, the shape of a tooth restoration filler being determined by measuring the preparing shape of the tooth on the basis of the MRI contrast medium which is measured by the MRI image device, the tooth restoration filler being manufactured by a three-dimensional cutter on the basis of the measured preparing shape of the tooth.

10. A device for making a tooth crowning filler comprising: an MRI image device which measures a cure tooth supplied with an MRI contrast medium which is rich in magnetic material; an electrical circuit which determines the shape of the cure tooth on the basis of the MRI contrast medium measured by the MRI image device; and a three-dimensional cutter which forms a tooth crowning filler on the basis of the shape of the cure tooth which is determined by the MRI image device.

11. A method for forming a prosthetic filler for a dental root of a cure tooth form which a dental pulp is removed, the dental root being supplied with an MRI contrast medium which is rich in magnetic material, and which is measured by a MRI image device, the shape of a tooth restoration filler being determined by measuring a shape of the dental root on the basis of the MRI contrast medium which is measured by the MRI image device, the tooth restoration filler being manufactured by a three-dimensional cutter on the basis of the shape of the dental root.

12. A method, device or MRI contrast medium according to any preceding claim wherein the magnetic material comprises hydrogen protons.

13. A method, device or MRI contrast medium according to any preceding claim wherein supplying the article with the contrast medium comprises coating the article with the contrast medium.

14. A measurement method using resonance of a resonance medium in which an insert probe is made from magnetic material and is to be inserted in a living body, the insert probe being measured by a MRI image device so as to determine a position of the insert probe in the living body.

15. A measurement method according to claim 14 wherein the insert probe is a preparing tool which removes a dental pulp of a cure tooth.

16. A measurement device using resonance of a resonance medium comprising: a resonance circuit which changes frequency according to a displacement of an article; a resonant frequency measuring device provided to measure a position of the article on the basis of the resonant frequency obtained from the resonant frequency measuring device.

17. A measurement device according to claim 16 further comprising: a calculator device which calculates a position of the article on the basis of the resonant frequency obtained from the resonant frequency measuring device.

18. A measurement device according to claim 16 or 17 wherein the resonant circuit is an LC-resonance circuit which changes its capacitance according to the displacement of the article and/or comprises an air variable capacitor which changes its capacitance according to the displacement of the article and/or an LC-resonance circuit which changes its inductance according to the displacement of the article.

19. A measurement device according to any one of claims 16 to 18 wherein the article comprises two members, each of which is movable to form rotational angles so as to change the resonant frequency of the resonant circuit according to the rotational angle between the two members.

20. A measurement device according to any one of claims 16 to 19 wherein the article comprises two members, each of which is movable to change the distance between the two members so as to change the resonant frequency of the resonant circuit according to the distance between the two members.

21. A measurement device according to any one of claims 16 to 20 wherein the resonant frequency measuring device comprises: an oscillating circuit for transmitting a continuously changing oscillating frequency; and a current measuring device for measuring an intensity of current supplied to the oscillating circuit so as to detect a resonant frequency of the resonant circuit according to change of the current measured by the current

measuring device.

22. A measurement device according to any one of claims 16 to 21 wherein the resonant circuit is an antenna resonant circuit which changes a received frequency according to the displacement of the article.

23. A measurement device according to claim 22 wherein the antenna resonance circuit is a rod type antenna which changes a length according to the displacement of the article.

24. A measurement device according to claim 22 or 23 wherein the antenna resonance circuit comprises: a cylindrical body in which a plurality of looped antennas are disposed at regular intervals; and a magnetic core disposed in the looped antennas of the cylindrical body, so that, in use, the resonant frequency changes according to how much the magnetic core is inserted into the looped antennas of the cylindrical body.

25. A measurement device according to claim 22, 23 or 24 wherein the antenna resonance circuit comprises: a cylindrical body in which a plurality of coiled antennas are disposed at regular intervals; and a magnetic core disposed in the coiled antennas of the cylindrical body, so that in use, the resonant frequency changes according to how much the magnetic core is inserted into the coiled antennas of the cylindrical body.

Fig. 1

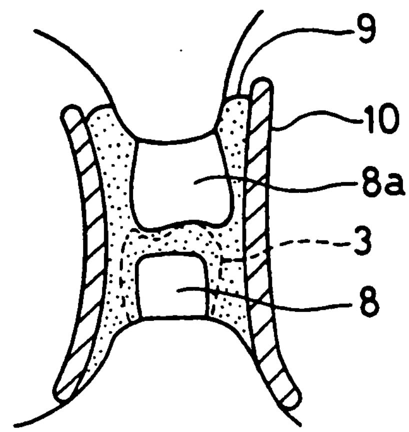


Fig. 2

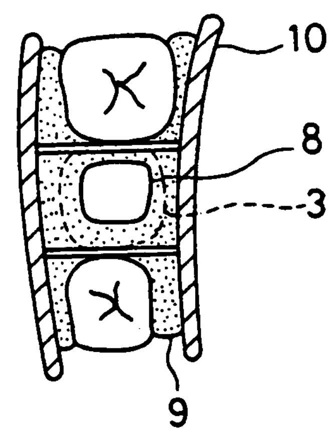
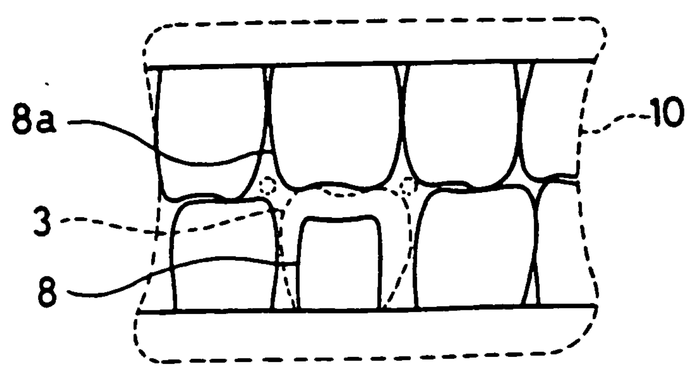


Fig. 3



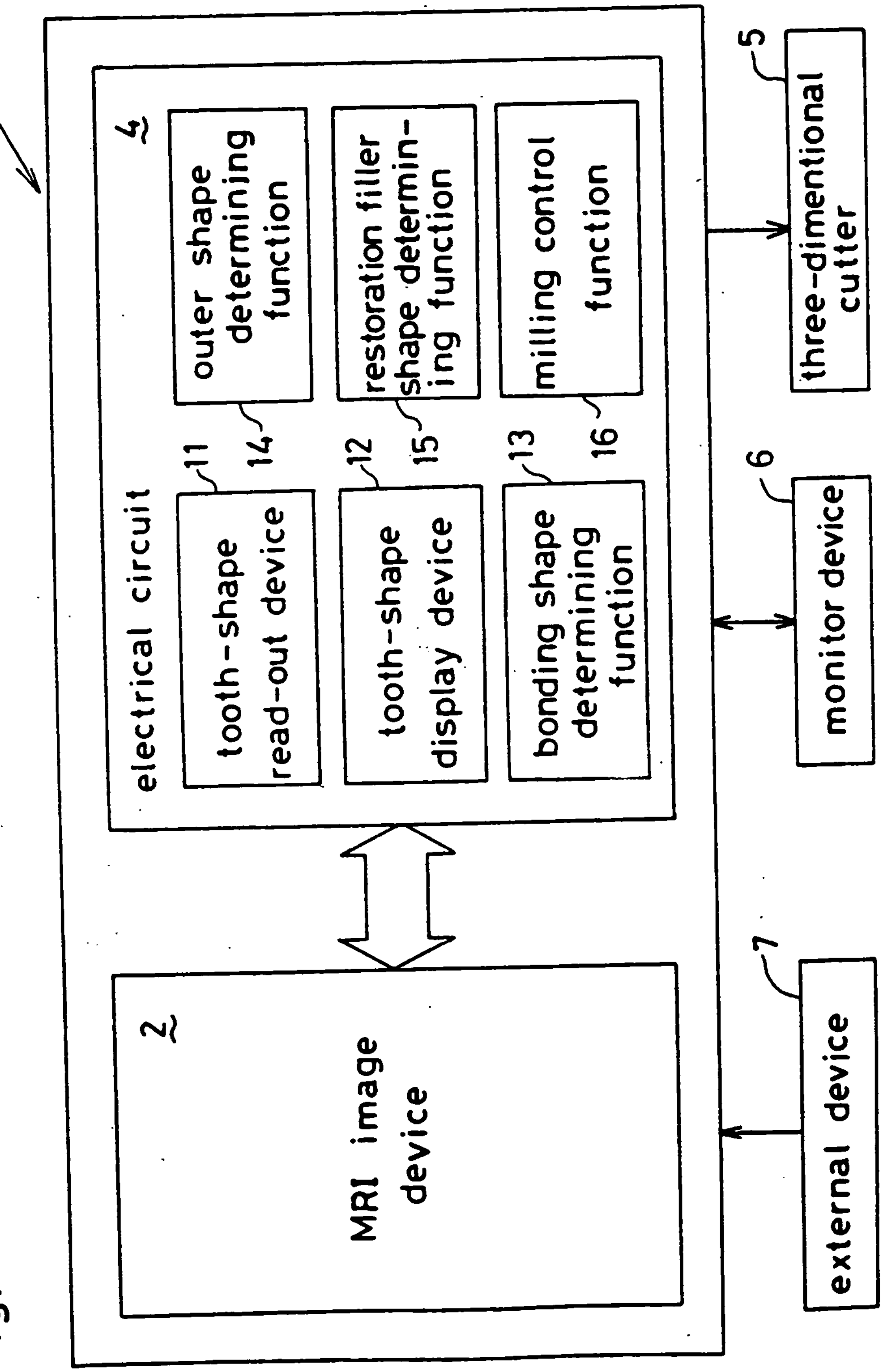

1
4
electrical circuit
outer shape determining function
restoration filler shape determining function
milling control function
14
15
16
11
12
13
tooth-shape read-out device
tooth-shape display device
bonding shape determining function
2
MRI image device
5
three-dimentional cutter
6
monitor device
7
external device

Fig. 4

Fig. 5

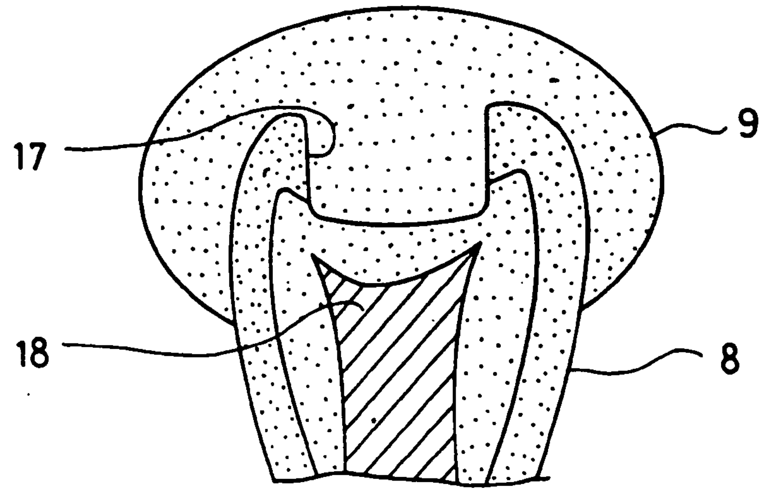


Fig. 6

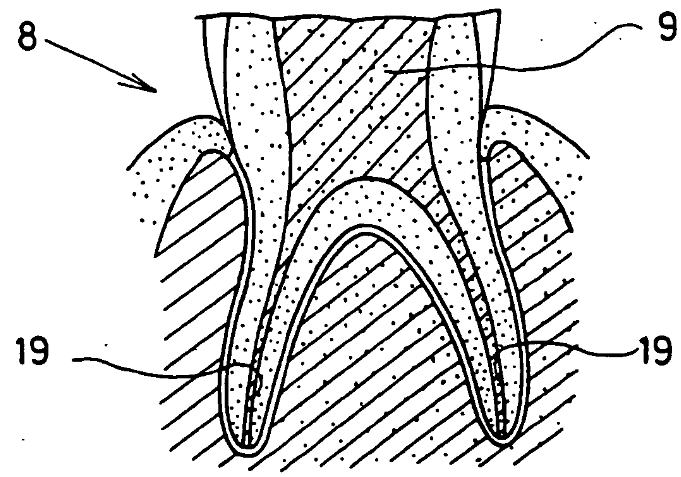


Fig. 7

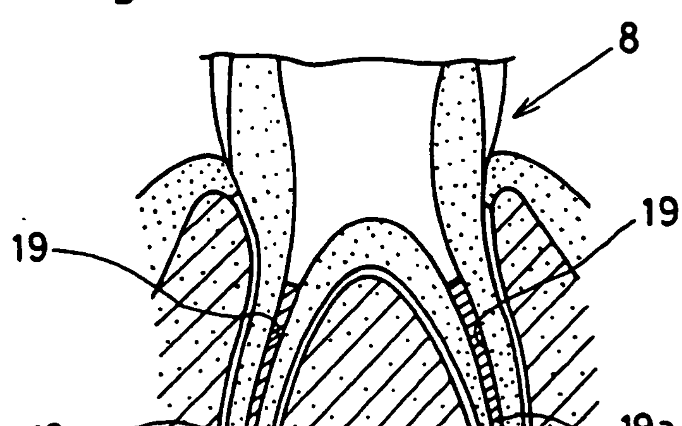


Fig. 8

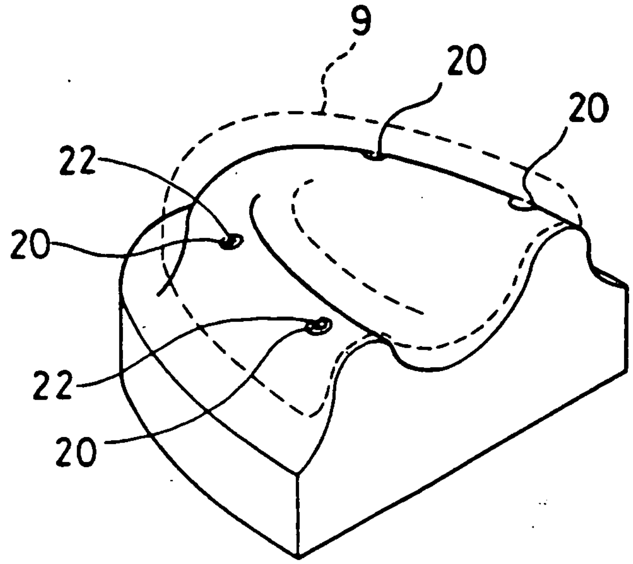


Fig. 9

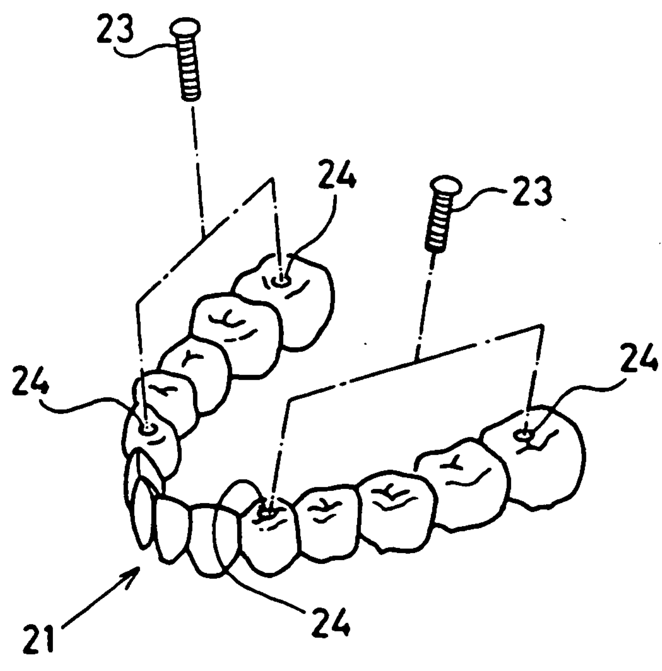


Fig.10

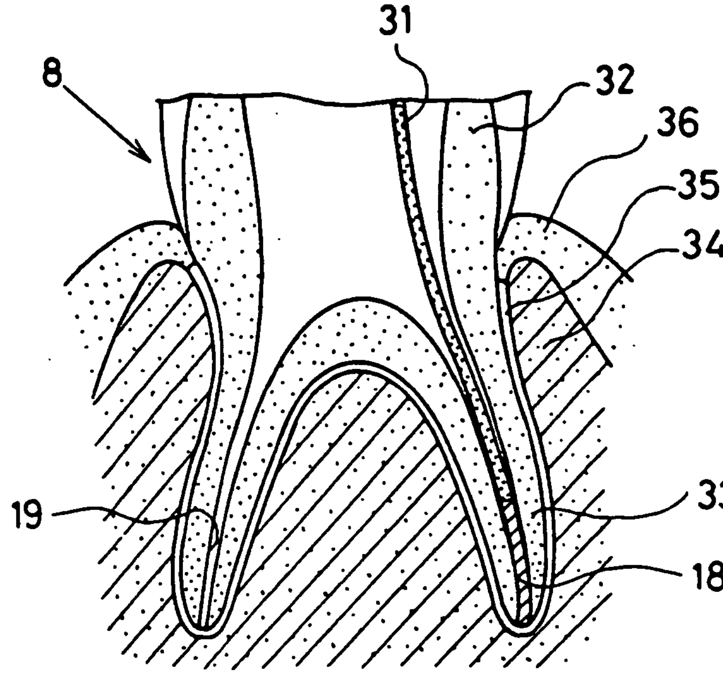


Fig.11

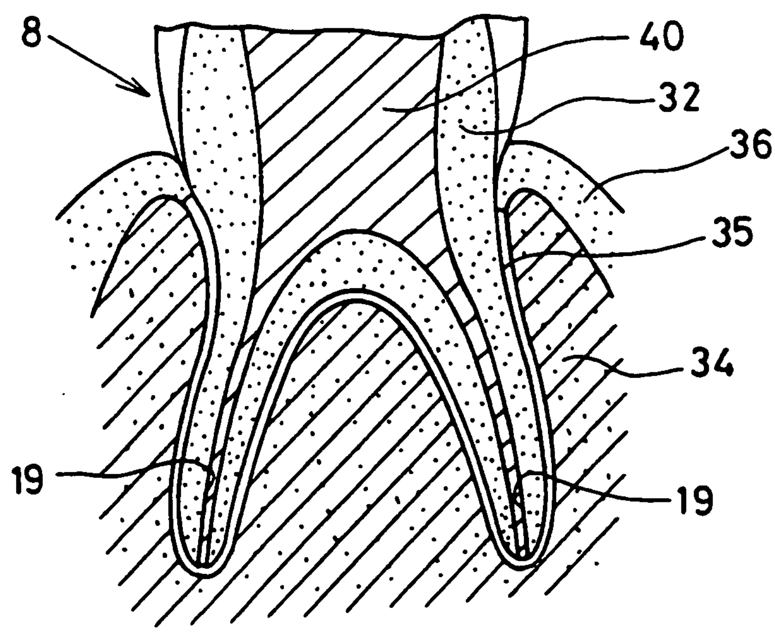


Fig. 12

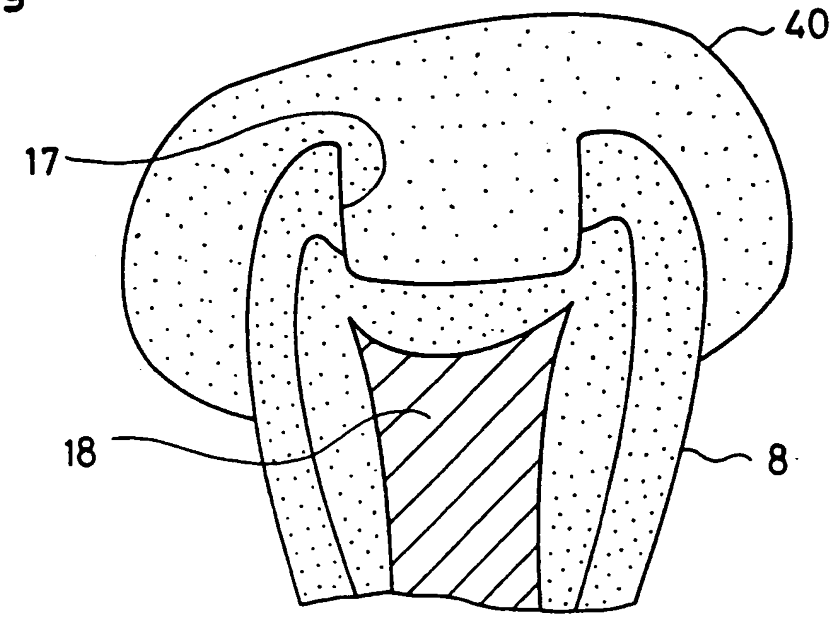


Fig.13

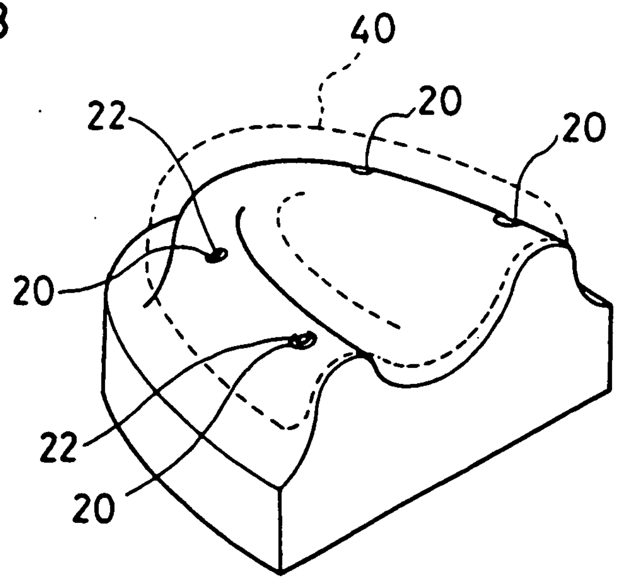


Fig. 14

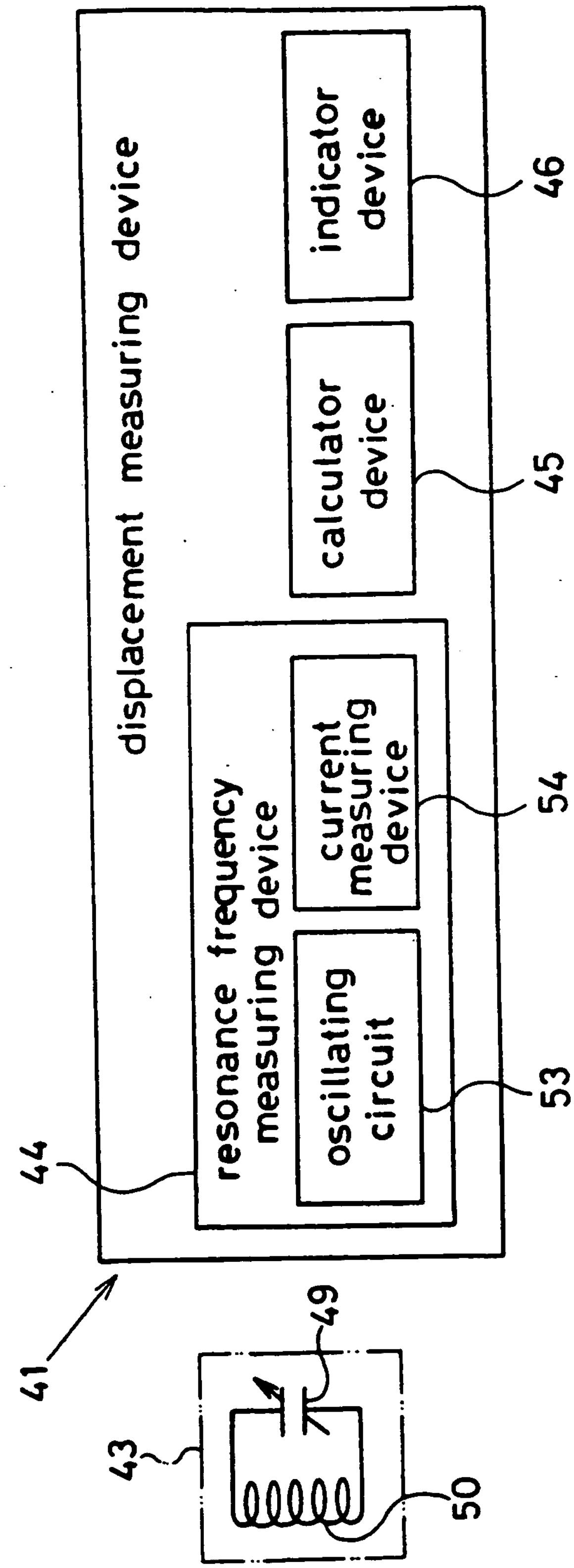

displacement measuring device
resonance frequency measuring device
oscillating circuit
current measuring device
calculator device
indicator device
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Fig. 15

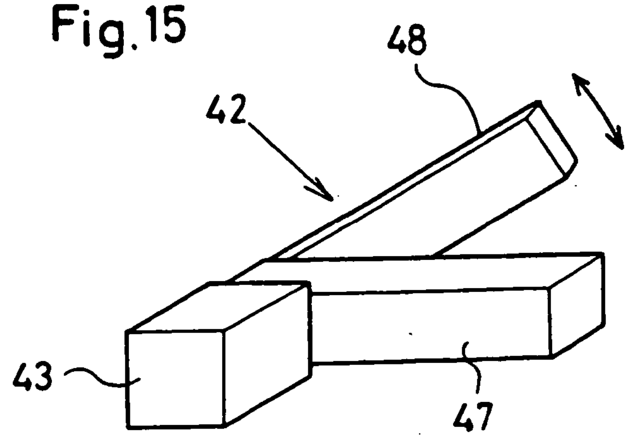


Fig. 16

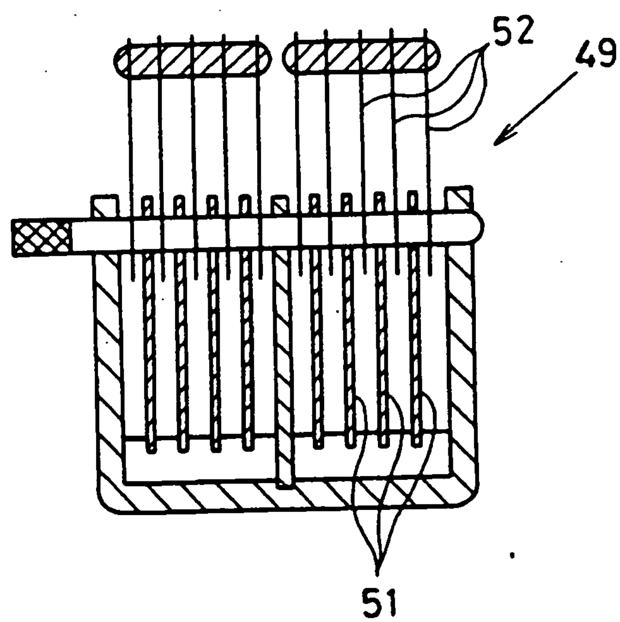


Fig. 17

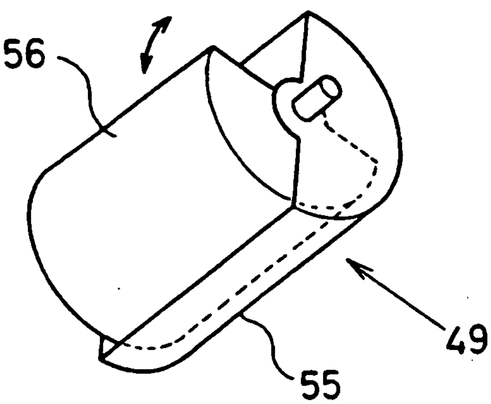


Fig. 18

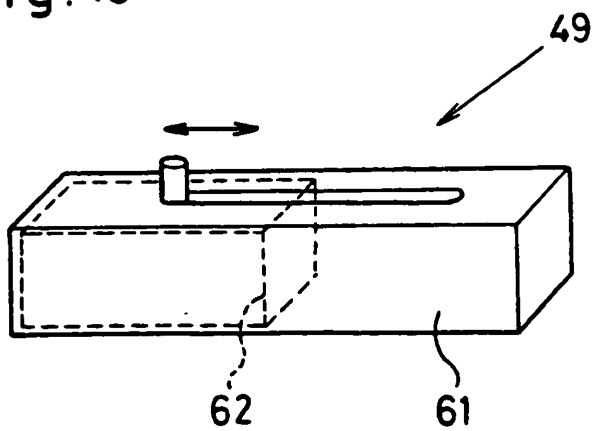
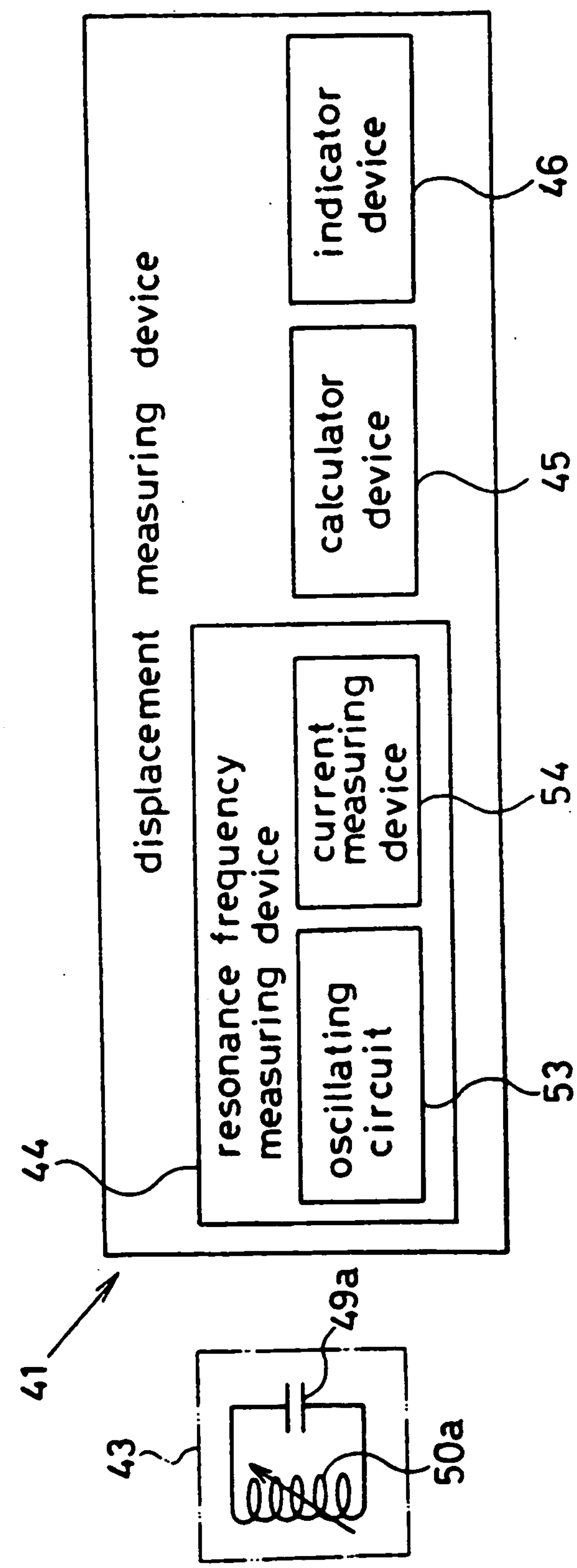


Fig.19


displacement measuring device
resonance frequency measuring device
oscillating circuit
current measuring device
calculator device
indicator device
41
43
44
45
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49a
50a
53
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Fig. 20

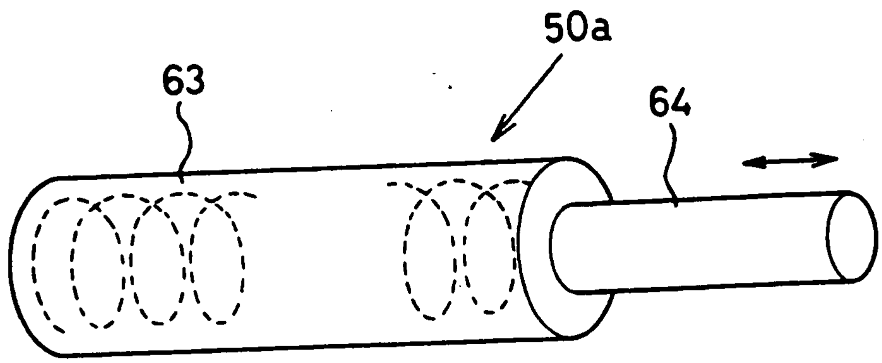


Fig. 21

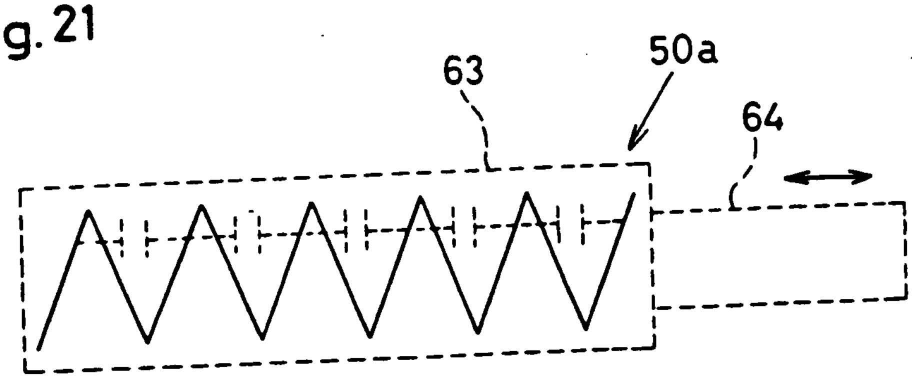


Fig. 22

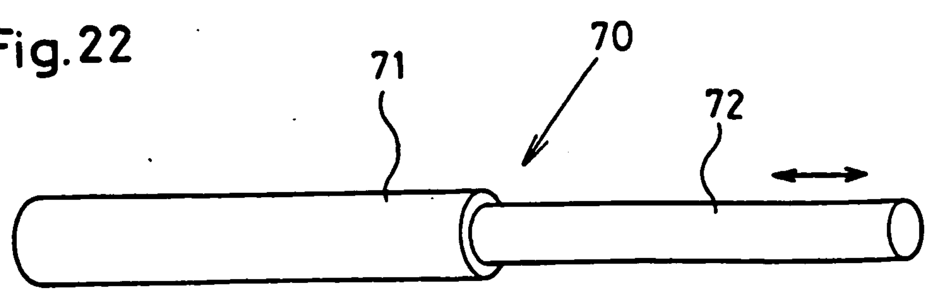


Fig. 23

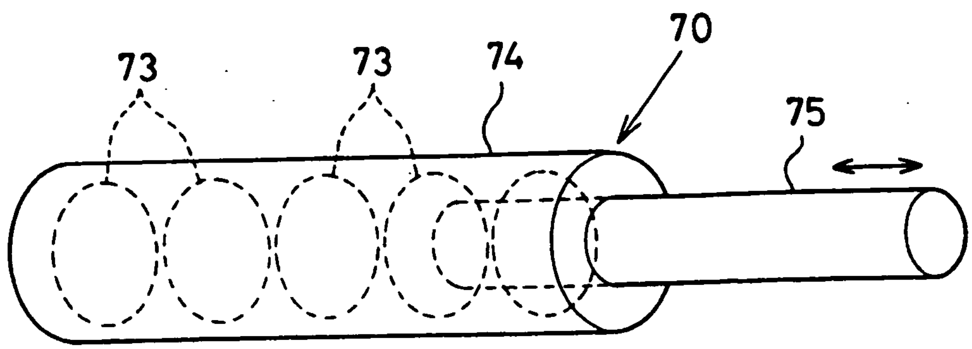
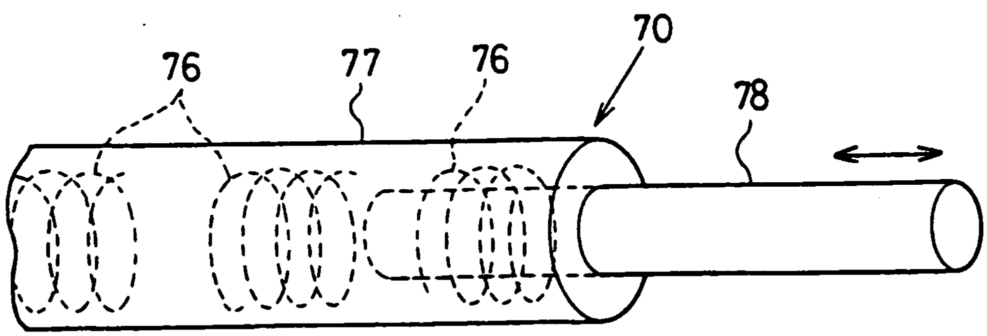


Fig. 24



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(71) Applicant: KABUSHIKI KAISHA EGAWA
14-ban, Karayama-cho, 1-chome,
Chikusa-ku
Nagoya-shi (JP)

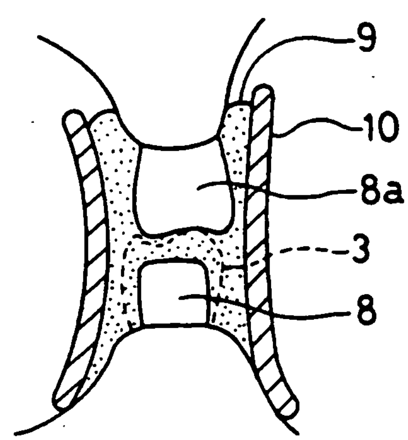
(72) Inventor: Nonomura, Yuusuke
14-ban, Karayama-cho 1-chome,
Chikusa-ku
Nagoya-shi (JP)

(74) Representative: Senior, Alan Murray et al
J.A. KEMP & CO.,
14 South Square,
Gray's Inn
London WC1R 5LX (GB)

(54) A measuring method using resonance of a resonance body.

(57) As a method of measuring a sectional figure of a living body by using a resonance medium in the living body, a MRI device has been introduced. However, the MRI device is not applied to bones, teeth which are poor in resonance-related protons, electrons and molecules. According to the invention, electrical, magnetic and electromagnetic fields are applied to the bones and teeth using a resonance medium. By using the resonance of the resonance medium, figure and displacement of the bones and teeth are measured. In more detail, proton spin and electric spin are applied to the bones and the teeth so that the spin state is measured to specify the figure and displacement by means of the MRI device. Otherwise, a resonance circuit which comprises the resonance medium is applied to the bones and teeth which changes rotationally and linearly. The resonance circuit changes its resonance frequency according to the displacement of articles to be measured. As one example, LC resonance circuit is exemplified which changes its inductance and capacitance, and an antenna circuit which changes the length.
Frequency which is changed by an oscillating circuit is applied to the resonance circuit. The resonance frequency is read out by an output change from the oscillating circuit influenced by the resonance of the resonance circuit. On the basis of the resonance frequency of the resonance circuit, the displacement of the article are measured. Alternatively, an echo-back method may be applied.

Fig. 1



EP 0 602 970 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 31 0160

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	SOCIETY OF MAGNETIC RESONANCE IN MEDICINE, ELEVENTH ANNUAL SCIENTIFIC MEETING, vol.1, 8 August 1992, BERLIN, GERMANY page 1518 B. VIKHOFF ET AL. 'ARTIFACTS CAUSED BY NEW DENTAL FILLING MATERIALS IN MAGNETIC RESONANCE IMAGING' * the whole document *	1,3	G01R33/56 A61K49/00 A61B5/05 G01B7/00 G01R33/28
Y		2,4, 12-14	
A		9-11	
Y	DE-A-36 14 142 (KABUSHIKI KAISHA TOSHIBA) * abstract * * page 13, line 7 - page 14, line 22 *	2,4,12, 13	
A		1-3	
Y	US-A-4 989 608 (A.V. RATNER) * abstract *	14	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	SOCIETY OF MAGNETIC RESONANCE IN MEDICINE, ELEVENTH ANNUAL SCIENTIFIC MEETING, vol.1, 8 August 1992, BERLIN, GERMANY page 1517 D.J. GILDERDALE ET AL. 'USE OF LOCAL RECEIVER COILS FOR DENTAL MRI' * the whole document *	1,2,5,6, 8,9	G01R A61K A61B G01B G01D
A	EP-A-0 329 402 (SCIENTIFIC GENERICS LTD) * column 1, line 38 - column 2, line 6 * * column 2, line 34 - column 3, line 36 *	1,2, 12-14	
A	WO-A-91 07911 (CONCAT LTD.) * abstract * * page 1, line 10 - page 2, line 10 *	1,2, 12-14	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 December 1994	Horak, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

European Patent Office

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- [ ] All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.
- [ ] Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid.

  namely claims:
- [ ] No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions.

namely:

see sheet -B-

- [x] All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims
- [ ] Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid.

  namely claims:
- [ ] None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims.

  namely claims:

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 31 0160

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	EP-A-0 136 812 (TECHNICARE CORPORATION) * abstract * * page 16, line 2 - line 29 *	1-3,12, 13	
X Y A	US-A-4 482 859 (J.M.A. FOURNIER) * column 2, line 22 - line 63; figure 1 *	16,18,22 17 19-21	
X Y A	PATENT ABSTRACTS OF JAPAN vol. 14, no. 162 (P-1029) (4105) 29 March 1990 & JP-A-02 019 712 (NAGANO KEIKI SEISAKUSHO K.K.) 23 January 1990 * abstract *	16,18 17 22	
X A	MESURES REGULATION AUTOMATISME, vol.51, no.5, 1 April 1986, PARIS FR pages 67 - 73 'DÉTECTEURS INDUCTIFS: DU TOUT OU RIEN À LA MESURE DU DÉPLACEMENT' * the whole document *	16,18,22 17,21	TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	EP-A-0 057 008 (CONTIS ELECTRONISCHE CONTROLINSTRUMENTE GMBH) * page 1, line 1 - page 7, line 3; figures 1,2,6,7 *	16,18, 22,24,25	
A	EP-A-0 168 691 (SIEMENS AKTIENGESELLSCHAFT) * abstract * * page 9, line 8 - page 12, line 10 *	16-18,22	

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EUROPEAN SEARCH REPORT

Application Number
EP 93 31 0160

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	EP-A-0 117 725 (KABUSHIKI KAISHA TOSHIBA) * page 1, line 18 - page 3, line 18 * ---	16-18,22	
A	US-A-4 364 046 (H. OGASAWARA ET AL.) * column 2, line 8 - column 3, line 63 * ---	16-20	
A	GB-A-2 085 594 (H. OGASAWARA) * page 2, line 4 - page 4, line 18 * ---	16-20	
A	US-A-5 107 211 (M. ROSE) * abstract * -----	16,19-21	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)

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European Patent Office

EP 93 31 0160 -B-

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims 1-15 : Method for measuring the shape of an article, especially from teeth or dental prosthesis, using an MRI contrast medium.

2. Claims 16-25 : Displacement measuring device using a change in the resonant frequency of the LC-resonant circuit.